Virtual National Laboratory for Heavy Ion Fusion
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HIF News

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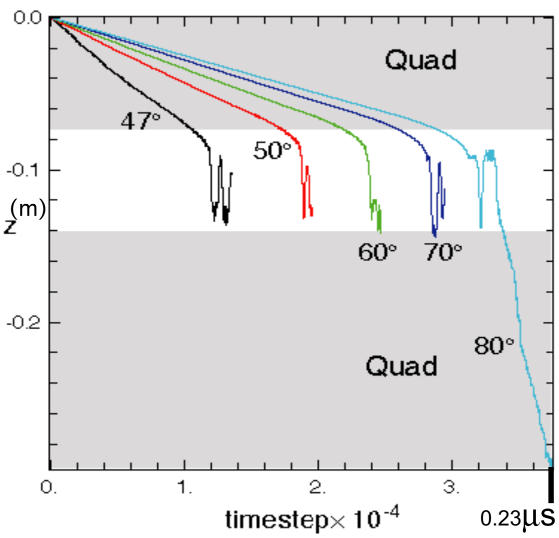
Electron Accumulation in HIF Accelerators

Electrons can accumulate in HIF accelerators from two main sources: ionization of ambient and desorbed gas by the ion beam, and secondary electrons from halo ions and electrons hitting walls. They can degrade beam quality by partially neutralizing or deflecting the beam and by inducing instabilities. Electron accumulation is of particular concern in magnetic quadrupoles, because of the close-fitting wall, the absence of the purging effect of electrostatic quadrupole fields, and the confining effects of the magnetic fields.



Axial histories for electrons launched at 1 cm radius and various azimuths from center of 15 cm long magnetic quadrupole. All curves end with loss to radial boundary.

Electrons are lost from a magnetic quadrupole through the combined electric and magnetic drifts. In the High-Current Experiment (HCX), with beam transport but no acceleration, the electrons are confined radially by the ion beam electrostatic potential. WARP code studies indicate that the electrons random-walk axially from magnetic quadrupole to magnetic quadrupole, residing in this portion of the accelerator for a time comparable to the 4 µs beam duration. Electrons from ionization of desorbed gas (the expected dominant source) should build up quadratically in time and be readily observable, as should be the effects of mitigation schemes.

The fate of electrons that drift out of a magnetic quadrupole is completely changed by accelerating fields in the gap. A single transit of an electron backwards (relative to ions) through an accelerating gap gives the electron enough energy to escape the beam's electrostatic potential. Orbit studies (see figure) indicate that most electrons will be lost to the walls in the order of the time to drift through a magnetic quadrupole. The result of multi-keV electrons impacting surfaces then becomes of interest. *– Ron Cohen, Art Molvik*

IBX Workshop held

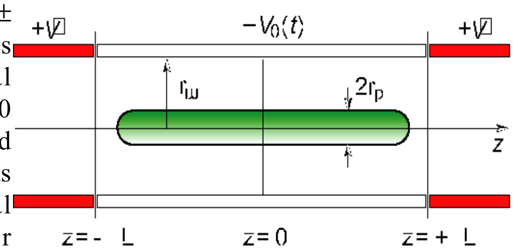
On Oct. 9-10, 2001 a workshop was held to outline the scientific mission and choose top-level design parameters for the Integrated Beam Experiment (IBX), a next-step experiment for the HIF-VNL. Forty-one people from the nationwide HIF community participated. Institutions represented included General Atomics, LBNL, LLNL, Mission Research Corporation, PPPL, and SNL. The IBX, as envisioned by VNL Director Grant Logan, would be an integrated source-to-target experiment, with a total project cost ~$40-60M. It would precede and be an intermediate step toward the IRE. The workshop included presentations from study groups that met in the preceding months to help explore the science and technology choices. Two sample designs were also presented, with preliminary costs. At the workshop a broad and exciting scientific mission for the IBX was defined. It included the first space-charge-dominated drift compression experiments, tests of short and intermediate wavelength longitudinal accelerator physics, measurements of electron effects in magnetic transport with acceleration, and integrated drift compression/bend/final focus/neutralization experiments. A consensus was reached on an IBX matched to this mission: a one beam magnetically-focused accelerator (possibly upgradeable to 4 beams), using a mass ~40 ion, and having initial pulse length of 0.2 - 2 µs, final kinetic energy of 10-20 MeV, and final line charge density of 1-2 µC/m following drift compression by a factor ~10. *– Christine Celata*

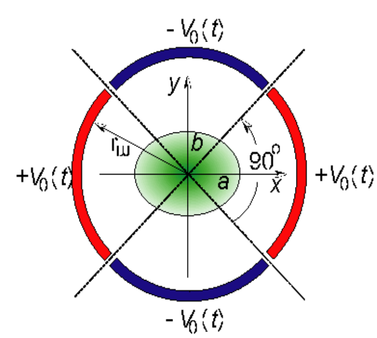
Paul Trap ion-beam simulator experiment

The Paul Trap Simulator Experiment (PTSX) is under construction at PPPL to study the propagation of intense beams in a compact laboratory setting. Studies will include: beam mismatch and envelope instabilities, collective wave excitations, chaotic particle dynamics and the production of halo particles, mechanisms for emittance growth, and the effects of the distribution function on stability properties.

The foundation of PTSX is the similarity between the equations that govern the behavior of an ion beam traveling through a spatially periodic set of quadrupole magnets and those that describe the behavior of ions in a cylindrical Paul trap under certain conditions. Varying the oscillating confining fields of the Paul trap allows us to simulate various magnetic quadrupole configurations that can include hundreds of magnet periods.

The trap will consist of a 2 m long, 20 cm diameter, gold plated, stainless steel cylinder that is axially sliced into four electrodes. Applying oscillating voltages $\pm V_0(t)$ to the electrodes provides radial confinement while 40 cm long biased electrodes at the ends provide axial confinement. For Barium, with $n = 10^7$ cm^{-3} and $V_{0\,max} = 400$ V, the oscillation frequency will be tens of kHz. We will use a dispenser cathode to emit Barium ions to load a plasma with r_p ~ 1 cm into the trap. We will measure the plasma's radial profile downstream with a moveable Faraday cup. Our plans include the eventual use of laser-induced-fluorescence (LIF) to make measurements of the full ion-distribution function. *– Erik P. Gilson*





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